Response of durum and bread wheats to nitrogen fertilizer

Yields of four wheats tested increased when nitrogen was applied up to 80 pounds per acre.

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Because quality and yield of all types of wheat are influenced by fertilization, a study was undertaken to determine the effects of various rates of applied nitrogen on grain yield, on physical and chemical characteristics of durum and bread wheats, and on the economics of nitrogen fertilization. The study was conducted in the irrigated, semiarid Tulelake Basin. Plantings were in mid-April each year.

Four rates of nitrogen were used to study the effect on yield and milling quality of durum and bread wheat from 1975 through 1977 on unclassified clay loam soil with 12 percent organic matter at Tulelake Field Station. To help minimize soil heterogeneity the soil had been previously cropped to barley without the application of fertilizer. Straw and stubble were plowed under after harvesting the barley each year. All plots received a preplant flood irrigation which saturated the soil to the 4-foot water table. One hundred-and-thirty pounds per acre of each bread and durum wheat cultivar were drilled 2 inches deep. An additional flood irrigation was made at the pre-boot stage. 2,4-D amine and Barban were applied to control weeds and wildoats.

In upper photo, taken in early June, no lodging of any of the four varieties of wheat tested has occurred with the application of 240 pounds of nitrogen per acre. Lower photo shows 80 percent of Leeds durum lodged at the 240-pound-per-acre application just before harvest in the first week of September, 1978.

Cultivars selected

Cultivars selected for the experiment were Modoc and Leeds durum wheats and Anza and Lark (WS1651) bread wheats. All except Leeds are short-statured and resist lodging. Nitrogen rates were 0, 80, 160, and 240 pounds per acre from ammonium sulfate (21 percent N) applied with a broadcast-type flow fertilizer spreader and immediately incorporated in the soil by discing. The experimental design was split-block with four N rates, four cultivars seeded in strips across N rates and four replications in a randomized complete block design. The original plot size was 50 feet long and 8 feet wide. An area 30 feet long and 4 feet wide was harvested by a combine.

Milling quality of wheat samples was evaluated by General Mills Quality Control Laboratories at Great Falls, Montana and at Vallejo, California. N content of wheat grain and flour was determined by the improved Kjeldahl method. Percent protein was determined by multiplying N in the wheat grain and flour by the factor 5.7. Moisture, test weight, and experimental milling were determined by standard procedures.

Results

Table 1 shows the yield of all varieties increased significantly through the 80-pounds-nitrogen-per-acre application rate. The yield of Modoc durum responded significantly in a linear fashion at all rates through 240 pounds of N per acre. Response of Modoc was curvilinear in 1977. Leeds durum did not respond significantly at N rates above 80 pounds per acre; a negative response occurred at rates above 160 pounds per acre where plant lodging was severe. The greatest yield increase for

Anza occurred at rates between 0 and 80 pounds and increased less at increments between 80 and 160, the least increase between 160 and 240 pounds of N per acre. Lark responded significantly to N applications through 160 pounds per acre, while yields reduced between 160 and 240 pounds per acre. Some lodging occurred with Lark at the 160 and 240 pounds N rate.

In this study test-weight reduction appeared to be associated with increased protein and flour ash. Higher protein consistently resulted in higher ash content except with Lark, which showed less ash content at higher grain protein. Grain protein of Modoc and Leeds increased linearly with each increment of N applied. Anza, when compared with Lark, showed a smaller increase in grain protein with each increment of additional N fertilizer, and flour protein followed the same pattern. Two durum wheats showed higher ash content in the flour (0.71 to 0.79 percent) compared with two bread wheats (0.42 to 0.46 percent).

Yellow semolina coloration of durum improved with increased N applications. However, ash content also increased in the same fashion; this resulted in some speckiness in the semolina at the 160 and 240 pounds N rates which reduced the quality of the flour. The endosperm of the Modoc durum seemed to absorb high mineral content with increased N.

In Lark yield and protein increased, but the ash content did not increase with additional N. High flour yield, high protein with strong gluten, and low flour ash content are all important in bread making. Lark, given additional N, appeared to have these properties, with a significant negative relationship between total production of grain protein per acre and flour ash.

Growers must consider the source and price of N fertilizer. Ammonium sulfate was used as a N source in this study, but anhydrous ammonia (NH_3-gas) can be substituted, if soil is not sulfur-deficient. The effect of sources of N fertilizer on yield, quality, and economic returns of wheat need to be evaluated more thoroughly in the Tulelake region.

Table 2 compares two sources of N for dollar returns per acre. This comparison is based upon the assumption that both N sources would perform similarly. The table also shows local costs per ton of anhydrous ammonia and ammonium sulfate. Present prices for Tulelake durum wheat (Modoc and Leeds) are $110 per ton or 5.5 cents per pound. Milling wheat prices (Anza and Lark) are $100 per ton or 5 cents per pound.

Considering the prices for N purchased and grain sold, farmers growing any of the above cultivars would consistently realize greater dollar return per acre by fertilizing with anhydrous ammonia rather than ammonium sulfate, if the soil had sufficient sulfur.

These tests indicate that when growing Modoc durum each increment of N through 240 pounds per acre resulted in increased yields and dollars returned per acre. Leeds durum reached maximum yield at 160 pounds N per acre, but its highest gross dollar per acre return was realized at 80 pounds N per acre. Anza wheat yielded highest with the addition of 240 pounds N per acre, but its greatest dollar return per acre was at 160 pounds N per acre. With Lark wheat, highest yields and greatest returns were obtained at 160 pounds N per acre.

Summary

Yields of four varieties of wheats increased with N applied up to 80 pounds per acre. Modoc durum yields increased significantly at rates through 240 pounds N per acre. Leeds durum yields did not respond significantly above 80 pounds N per acre and yield decreased at rates above 160 pounds. Anza showed greatest response between 0 to 80 pounds, but showed an increased yield curvilinearly through 240 pounds of N per acre. Lark yields increased with each increment of N through 160 pounds per acre; its greatest increase was between 0 to 80 pounds N per acre, but yield decreased at 240 pounds N per acre. With the exception of Anza, grain and flour protein increased with applied N in all cultivars. Ash content increased in the two durum varieties, increased slightly in Anza, but was lowered in Lark with N applications. Yellow color of semolina improved with increased N in the durum, but some speckiness developed at the high N rates.

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TABLE 1. Nitrogen Affect on Wheat Yield and Quality.

Culitvar	Nitrogen lbs/acre	Yield lbs/acre	Test wt lbs/bu	% Grain protein	% Flour protein	% Flour ash
Durum wheat						
Modoc	0	4020	64.1	12.4	10.7	0.73
	80	5350	65.3	12.7	10.4	0.75
	160	5890	64.1	13.4	11.8	0.77
	240	6450	64.3	13.6	12.2	0.79
Leeds	0	4260	63.6	11.9	10.5	0.71
	80	4630	63.9	12.8	10.9	0.72
	160	4830	63.6	13.6	11.7	0.77
	240	4230	62.7	14.4	12.4	0.78
L.S.D. at 0.05%	Nitrogen	400	N.S.	0.05	0.6	0.04
	Cultivar	210	N.S.	0.23	N.S.	N.S.
Cultivar X	Nitrogen	400	N.S.	0.23	N.S.	N.S.
Bread wheat						
Anza	0	4990	61.0	11.3	10.1	0.43
	80	6120	60.5	11.2	10.0	0.46
	160	6680	59.0	11.3	10.2	0.44
	240	6820	60.0	11.8	10.3	0.44
Lark	0	4680	62.3	12.8	11.1	0.42
	80	5600	60.7	12.9	11.6	0.43
	160	6320	60.7	13.7	12.0	0.43
	240	5840	60.3	14.4	12.4	0.42
	Nitrogen	400	N.S.	0.60	N.S.	N.S.
	Cultivar	210	N.S.	1.50	N.S.	N.S.
Cultivar &	Nitrogen	400	N.S.	N.S.	0.50	N.S.

TABLE 2. Comparison of Economic Return from Two Nitrogen Sources.

Cultivar	Nitrogen lbs/acre	Production Cost* Nitrogen Source Anhy. Am.†	Production Cost* Nitrogen Source Am. Sul.†	Profit/acre Nitrogen Source Anhy. Am.	Profit/acre Nitrogen Source Am. Sul
Modoc	0	$242.10	$242.10	$(21.00)	$(21.00)
	80	261.55	268.75	32.70	25.50
	160	277.05	291.45	46.90	32.50
	240	288.00	314.40	63.60	42.00
Leeds	0	243.30	243.30	(9.00)	(9.00)
	80	256.35	265.15	(3.30)	(10.50)
	160	271.75	286.15	(6.10)	(20.50)
	240	281.55	303.15	(48.90)	(70.50)
Anza	0	246.95	246.95	2.50	2.50
	80	264.60	272.60	41.40	33.40
	160	279.40	295.40	54.60	38.60
	240	292.10	316.10	48.90	24.90
Lark	0	245.40	245.40	(11.40)	(11.40)
	80	262.00	270.00	18.00	10.00
	160	277.00	293.00	38.40	22.40
	240	287.00	311.20	4.80	(19.20)

Note: Anhydrous ammonia at $265/ton (16¢/lb N) contains 82% N. Ammonium Sulfate at $105/ton (25¢/lb N) contains 21% N.

*Includes all fixed costs at $222 per acre and depreciation, interest and management fee.

†Includes all fixed costs plus fertilizer and harvesting costs.